

# EOS-AM2 MISSION

PRESENTATION TO SCIENCE  
WORKING GROUP, AM PROJECT

GSFC

APRIL 4, 1997

R. TAYLOR

# **MISSION ASSUMPTIONS**

- **LANDSAT AND EOS-AM MISSIONS MERGE AFTER LANDSAT-7 AND EOS-AM1**
  - **THE FIRST SPACECRAFT IS EOS-AM2**
- **LAUNCH DATE IS JUNE 2004**
- **MEASUREMENT COMPLEMENT ENCOMPASSES THE MEASUREMENTS OF MODIS, MISR, ETM+, CERES, EOSP**
- **SPACECRAFT IS COMPATIBLE WITH GROUND STATIONS AND WITH THE EOS GROUND SYSTEM**
- **ACCOMMODATE LANDSAT INTERNATIONAL GROUND STATIONS**

# **MISSION OBJECTIVES**

- **MEET REQUIREMENTS OF MTPE SCIENCE RESEARCH PLAN AND LANDSAT FOLLOW-ON (P.L. 102-555)**
  - **MEASUREMENT CONTINUITY**
  - **CO-REGISTRATION**
  - **GEOLOCATION**
  - **INTERNATIONAL LANDSAT GROUND STATIONS**
- **INCORPORATE LESSONS LEARNED FROM EOS-AM1 AND LANDSAT-7**
  - **CALIBRATION MANEUVERS**
- **INCORPORATE ADVANCED TECHNOLOGIES FOR IMPROVED SYSTEM PERFORMANCE**

# **MISSION DESIGN OPTIONS**

- **FLY COPIES OF EXISTING INSTRUMENTS AND SPACECRAFT**
  - MINIMAL DEVELOPMENT
  - LOWEST RISK
  - STATIC TECHNOLOGY
  - EXISTING INFRASTRUCTURE (ALGORITHMS, SPACECRAFT)
- **FLY EVOLUTIONARY INSTRUMENTS AND SPACECRAFT**
  - MODIFY BASIC DESIGN
  - REPLACE OBSOLETE ELEMENTS
  - INFRASTRUCTURE MAY REQUIRE MODIFICATIONS
- **NEW DESIGN**
  - NEED DEVELOPMENT
  - HIGHER RISK
  - DYNAMIC TECHNOLOGY
  - INFRASTRUCTURE MUST BE MODIFIED
  - COST TRADE MUST BE UNDERSTOOD
- **RELY ON OTHER PROVIDERS (COMMERCIAL, INTERNATIONAL, OTHER AGENCY)**
  - ACCEPT WHAT IS PROVIDED

# SUMMARY OF OPTIONS

OPTION	1	2	3	4	5	6
	BASELINE	ATLAS	LIGHT	INTEGRATED	FORMATION FLYING	DOCKING
DESCRIPTION	894 BASELINE	UTILIZE AM-1 DESIGN	MODIFY INSTRUMENTS	INTEGRATED PAYLOAD ARCHITECTURE	FORMATION FLYING OF PAYLOAD	ORBITAL ASSEMBLY OF PAYLOAD COMPLEMENT
INSTRUMENTS	MODIS MISR ETM+ OR NEW TECHNOLOGY CERES EOSP	MODIS MISR ETM+ OR NEW TECHNOLOGY CERES EOSP	MODIS / LIGHT MISR / LIGHT ETM+ / LIGHT OR NEW TECHNOLOGY CERES EOSP	MODIS BANDS + OPTICS + A/D ONLY MISR BANDS + OPTICS + A/D ONLY ETM+ BANDS + OPTICS + A/D ONLY CERES EOSP	MODIS BANDS + OPTICS + A/D ONLY MISR BANDS + OPTICS + A/D ONLY ETM+ BANDS + OPTICS + A/D ONLY CERES EOSP	MODIS BANDS + OPTICS + A/D ONLY MISR BANDS + OPTICS + A/D ONLY ETM+ BANDS + OPTICS + A/D ONLY CERES EOSP
--- NOTES ON INSTRUMENTS	INSTRUMENTS AS CURRENTLY EXIST (OR NEW TECHNOLOGY FOR LANDSAT MEASUREMENTS).	INSTRUMENTS AS CURRENTLY EXIST (OR NEW TECHNOLOGY FOR LANDSAT MEASUREMENTS).	'LIGHT' INSTRUMENTS ARE SEPARATE INSTRUMENTS DERIVING FROM EXISTING INSTRUMENTS, PROBABLY FROM CURRENT DEVELOPERS, DELETE MOST DATA HANDLING AND CONTROL ELECTRONICS	IMAGERS ARE INTEGRATED SET, POSSIBLY FROM A SINGLE DEVELOPER.	IMAGING SYSTEMS WITHIN A SINGLE GROUP OF BANDS (MODIS, MISR, ETM+) ARE STAND ALONE SYSTEMS.	IMAGING SYSTEMS WITHIN A SINGLE GROUP OF BANDS (MODIS, MISR, ETM+) ARE STAND ALONE SYSTEMS
SPACECRAFT	COMMON	AM1 OPTION B	SIZE IN STUDY	SIZE IN STUDY	SIZE 5 SPACECRAFT IN STUDY	SIZE 5 SPACECRAFT IN STUDY
--- NOTES ON SPACECRAFT	MODIFICATIONS REQUIRED FOR REVISED INSTRUMENT PAYLOAD	AM1 OPTION B DOES NOT INCLUDE INSTRUMENT INTEGRATION.	SPACECRAFT INCORPORATES DATA BUFFERS, COMPUTING, AND POWER CONDITIONING REQUIRED BY 'LIGHT' INSTRUMENTS.	SPACECRAFT INCORPORATES DATA BUFFERS, COMPUTING, AND POWER CONDITIONING REQUIRED BY INTEGRATED IMAGER SET. DATA SYSTEM IS PART OF SPACECRAFT CONTRACT, OR GFE.	5 STAND ALONE SPACECRAFT, ONE INSTRUMENT PER SPACECRAFT, FLOWN AND MAINTAINED IN PROXIMITY.	ONE SPACECRAFT MAKES CORE SUPPORT SERVICES SYSTEM PLUS ONE INSTRUMENT. FOUR ADDITIONAL SPACECRAFT, ONE INSTRUMENT PER SPACECRAFT, ALL DOCKED TO CORE SYSTEM.
LAUNCH VEHICLE	DELTA	ATLAS IIAS	DETERMINE IN STUDY, PROBABLY DELTA	DETERMINE IN STUDY, PROBABLY DELTA LITE OR SMALLER	DETERMINE IN STUDY, PROBABLY: 4 - 5 TAURUS OR PEGASUS 3 - 5 LLV	DETERMINE IN STUDY, PROBABLY: 4 - 5 TAURUS OR PEGASUS 3 - 5 LLV
NUMBER OF LAUNCHES	1	1	1	1	4 - 5 TAURUS OR PEGASUS 3 - 5 LLV	4 - 5 TAURUS OR PEGASUS 3 - 5 LLV
OPTIONAL SENSORS	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).	NEW TECHNOLOGY SENSOR (OPTICAL, SAR).
LAUNCH COSTS	\$44 - 51M	\$105 - 115M	\$44 - 51M	\$25 - 30M	\$95 - 115M	\$95 - 115M
P% FOR PUTTING COMPLETE PAYLOAD ON ORBIT	0.99	0.83	0.99	TBD - 0.99	0.03 - 0.5 (PEGASUS)	0.03 - 0.5 (PEGASUS)
CONCERNS	1. VIABILITY OF COMMON SPACECRAFT USAGE POST X-1 PHASE OF EOS 2. FIELD OF VIEW OBSTRUCTIONS 3. POINTING PERFORMANCE 4. DATA RATE PERFORMANCE 5. DATA CAPACITY PERFORMANCE	1. VIABILITY OF CONTINUED USE OF ATLAS 2. AVAILABILITY OF PARTS IN 1996 TO 2004 TIME FRAME 3. AVAILABILITY OF TDRSS	1. VIABILITY OF COMMON SPACECRAFT USAGE POST X-1 PHASE OF EOS 2. POINTING PERFORMANCE 3. DATA RATE PERFORMANCE 4. DATA CAPACITY PERFORMANCE	1. NEW TECHNOLOGY MUST BE DEMONSTRATED 2. COMMITMENT OF SCIENCE COMMUNITY TO INTEGRATE FUNCTIONS (DELETE FROM SINGLE INSTRUMENTS)	1. REDUCED PROBABILITY OF SUCCESSFUL CONSTELLATION 2. RELIABILITY OF PEGASUS 3. INCREASED LAUNCH COSTS 4. INTEGRATION OPPORTUNITIES LIMITED 5. POINTING CONCERNS 6. LAUNCH WINDOW CONSTRAINTS 7. COMMUNICATIONS CONCERNS 8. GROUND OPS COMPLICATED 9. DATA PROCESSING OR SCIENCE CONCERNS	1. REDUCED PROBABILITY OF SUCCESSFUL CONSTELLATION 2. RELIABILITY OF PEGASUS 3. INCREASED LAUNCH COSTS 4. INTEGRATION OPPORTUNITIES LIMITED 5. POINTING CONCERNS 6. LAUNCH WINDOW CONSTRAINTS
DEMO REQUIRED	NO	NO	NO	YES - SATISFY USER COMMUNITY OF FULL CONTINUITY	NO - FOR FORMATION FLYING (ALREADY DONE) YES - FOR INSTRUMENT SUITE CHANGES	NO - FOR RENDEZVOUS AND DOCKING ROUTINELY DONE BY RUSSIANS YES - FOR INSTRUMENT SUITE CHANGES

# TECHNOLOGY CONSIDERATIONS FOR THE AM-2 ERA

## INSTRUMENTS

### ADVANCED GLOBAL IMAGER

OBJECTIVES	SATISFY NOAA OPERATIONAL NEEDS IMPLEMENT IMPROVED UNDERSTANDING FROM MODIS DEVELOPMENT AND OPS
TRADES	SCANNER OR PUSHBROOM SINGLE OR MULTIPLE IMAGER UNITS REFLECTIVE OR REFRACTIVE OPTICS MULTISPECTRAL OR HYPERSPECTRAL CALIBRATION (ON-BOARD, GROUND-BASED ACTIVE, MANEUVERS) GEOLOCATION (REALTIME OR POST-PROCESSED) CO-REGISTRATION (REALTIME OR POST-PROCESSED)
TECHNOLOGY	QWIP OR BOLOMETER ARRAY DETECTORS (TIR) INGAS OR SI DETECTORS (SWIR) STIRLING CYCLE, PULSE TUBE, OR PASSIVE COOLERS DATA COMPRESSION
DRIVERS	STABILITY, POINTING KNOWLEDGE, COOLING, DATA RATE

## HIGH RESOLUTION IMAGER

### OBJECTIVES

SATISFY REQUIREMENTS OF P.L. 102-555  
IMPROVEMENT OVER ETM+ AND PROPOSED COMMERCIAL  
IMPLEMENT IMPROVED UNDERSTANDING FROM ETM+ EXPERIENCE

### TRADES

SCANNER OR PUSHBROOM OR STARING ARRAY  
SINGLE OR MULTIPLE IMAGER UNITS  
REFLECTIVE OR REFRACTIVE OPTICS  
THERMAL BAND  
ACTIVE OR PASSIVE  
MULTISPECRAL OR HYPERSPECTRAL  
CALIBRATION (ON-BOARD, GROUND-BASED, MANEUVERS)  
GEOLOCATION (REALTIME OR POST-PROCESSED)  
CO-REGISTRATION (REALTIME OR POST-PROCESSED)

### TECHNOLOGY

INGAS OR SI DETECTORS (SWIR)  
ACTIVE OR PASSIVE PIXEL ARRAYS  
ACTIVE OR PASSIVE COOLING  
DISCRETE OR WEDGE FILTER, OR GRATING

### DRIVERS

SPACECRAFT STABILITY, COOLING, POINTING KNOWLEDGE, DATA RATE  
COMMUNICATIONS (REGULAR DOWNLINK AND INTERNATIONAL USERS)

## ADVANCED MISR

### OBJECTIVES

BRDF (BI-DIRECTIONAL REFLECTANCE DISTRIBUTION FUNCTION) AND AEROSOLS

### TRADES

NINE OR FIVE CAMERAS

REFRACTIVE OR REFLECTIVE OPTICS

PASSIVE OR ACTIVE PIXEL ARRAYS

FOUR BANDS OR EIGHT BANDS

CALIBRATION (ON-BOARD, GROUND-BASED, MANEUVERS)

GEOLOCATION (REALTIME OR POST-PROCESSED)

CO-REGISTRATION (REALTIME OR POST-PROCESSED)

### TECHNOLOGY

ACTIVE PIXEL ARRAYS

### DRIVERS

STABILITY, POINTING KNOWLEDGE, COOLING, DATA RATE

## CERES

### OBJECTIVES

IMPLEMENT IMPROVED UNDERSTANDING IDENTIFIED DURING CERES DEV.

### TRADES

COPY OR NEW DEVELOPMENT

### DRIVERS

DISTURBANCE (REACTION TORQUE)

## EOSP

### OBJECTIVES

IMPLEMENT NEW SCIENCE AND NEW MEASUREMENTS

### TRADES

ALONG-TRACK OR CROSS-TRACK SCANNER

NUMBER OF BANDS

FILTER TECHNIQUES (DISCRETE OR PEM)



# SPACECRAFT

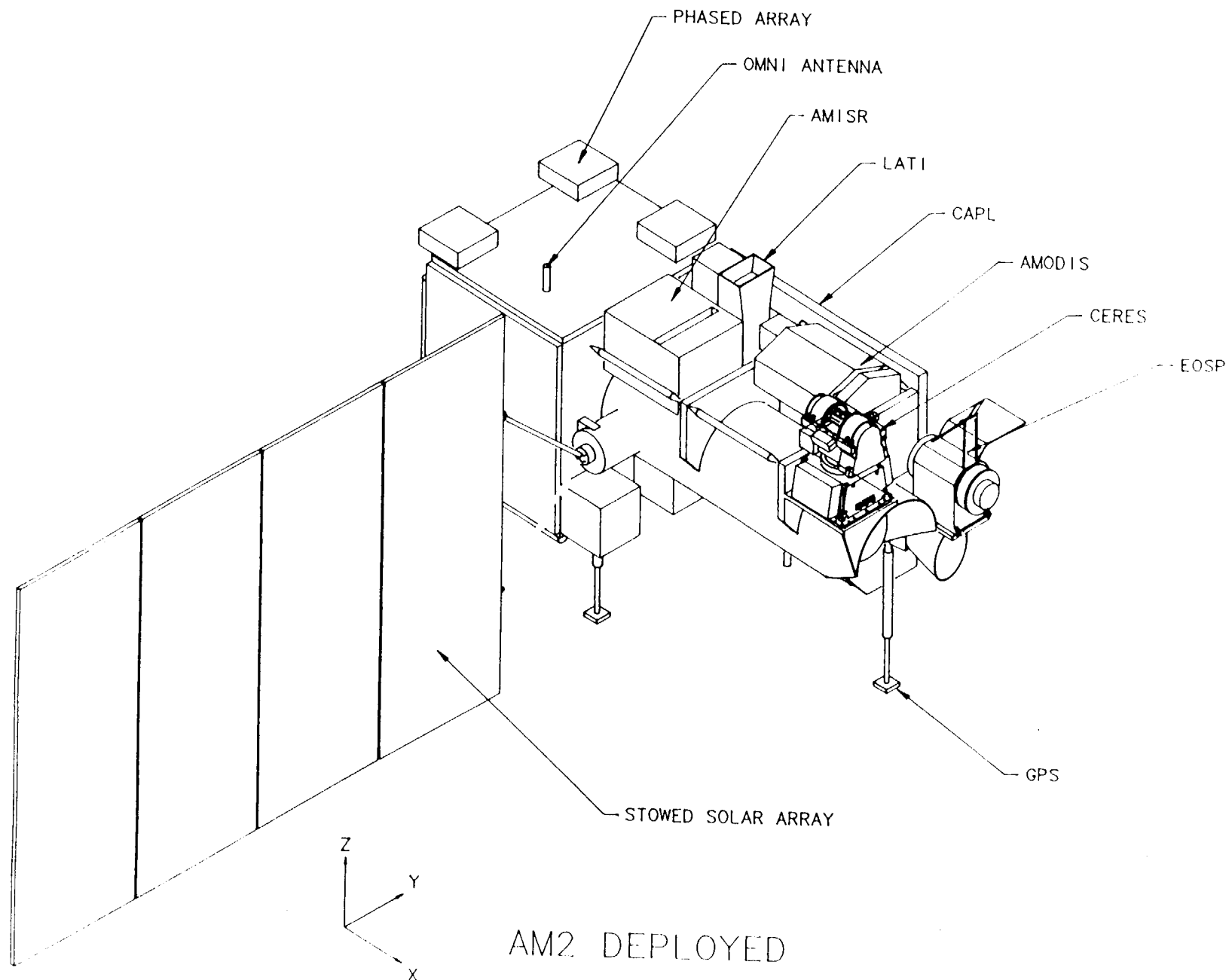
## OBJECTIVES

AUTONOMOUS OPERATIONS  
DISTRIBUTE DATA TO USERS  
REDUCE COST AND DEVELOPMENT TIME

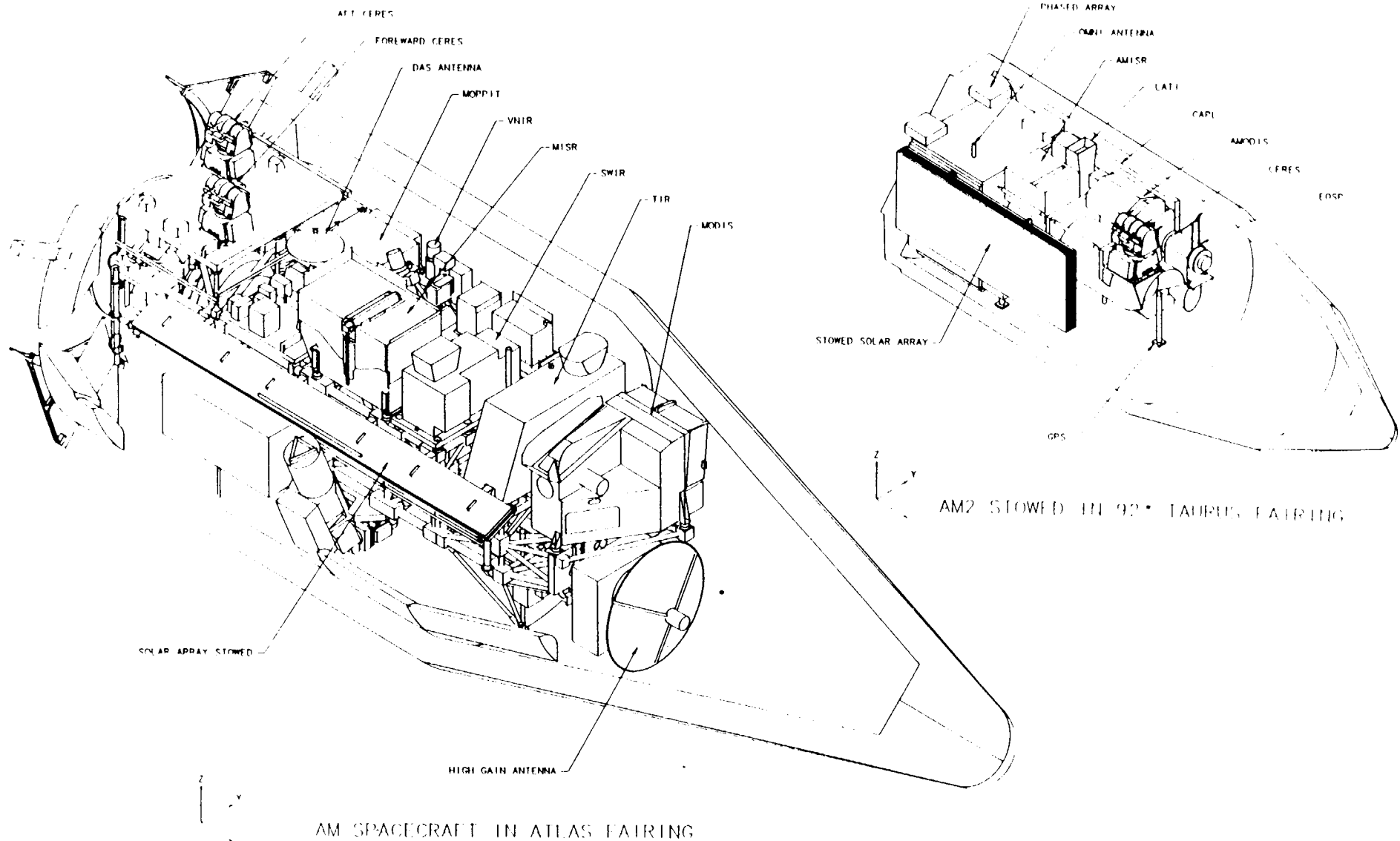
## TRADES

NUMBER OF SPACECRAFT (ONE, THREE, FIVE, SEVEN)  
DOWNLINK (PHASED ARRAY KU, KA, OPTICAL)  
STAR CAMERAS OR STAR TRACKERS  
INTEGRATED OR DISTRIBUTED DATA SYSTEM  
ACTIVE DISTURBANCE SUPPRESSION  
FORMATION FLYING CONTROL (ACTIVE OR PASSIVE)

# EXAMPLE INSTRUMENT ACCOMMODATION FOR OPTION 4

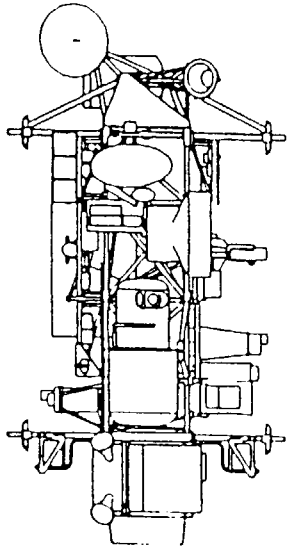


# COMPARISON OF OPTION 4 EOS AM-2 CONCEPT TO EOS AM-1

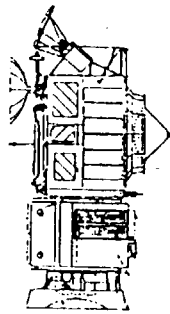


**OPTIONS 4 AND 5 YIELD CONSIDERABLY SMALLER SPACECRAFT**

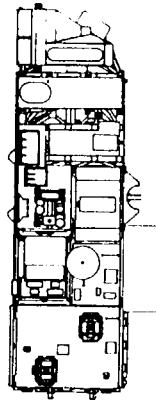
# Spacecraft Comparisons



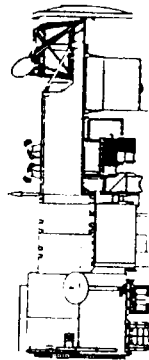
UARS



TOPEX/  
POSEIDON



EOS-AM1



EOS-PM1



LANDSAT-4



NIMBUS-7



EOS-AM2



SEASTAR

# EXAMPLE CONSTELLATION NAVIGATION AND GEOLOCATION REQUIREMENTS

EOS-AM2 SPACECRAFT TRIAD (0.1 pixel coregistration criterion)

	Simultaneity (min)		Pixel Geolocation Knowledge (m, $3\sigma$ ) AT/XT	S/C Position Knowledge (m, $3\sigma$ ) AT-XT-R	Pointing Knowledge (arcsec, $3\sigma$ )	Pointing Accuracy (arcsec, $3\sigma$ )
MODIS-CERES	}	}	71/71	20-20-20 Geode	20-20-20	360-360-360 <sup>2</sup>
	} 3.5	}		5-5-5 WAAS	21-21-21	
MISR-EOSP	}	} 1 cloud studies	71/71	20-20-20 Geode	20-20-20	1373-1373-1373 <sup>2</sup>
		} 15 aerosol corr.		5-5-5 WAAS	21-21-21	
LATI	}	}	71/71	20-20-20 Geode	20-20-20	180-180-180
		}		5-5-5 WAAS	21-21-21	

# EXAMPLE RELATED INTERNATIONAL INSTRUMENTS

Instrument Name	Agency	Mission <sup>1</sup>	Mass (kg)	Power (W)	D. Rate (Mbps)	AM2 Replacement
PRISM (Hyperspectral & TIR 50m Imager)	ESA	EE(> '02)	400	400	260	LATI?
MERIS (Land or Ocean Color)	ESA	EW(> '02)	180	230	24-1.6	MODIS(VNIR)?
AATSR	ESA/UK	EW(> '02) METOP-1('01)	99	111	0.7	MODIS(SST's)
SCARAB	ESA/CNES	EE(> '02) METOP-1('01)	42 <sup>2</sup>	40-60 <sup>2</sup>	0.001 <sup>2</sup>	CERES
POLDER 3	CNES	ADEOS-3('05)? EE(> '02)?	32	50	0.882	EOSP
GLI 2	NASDA	ADEOS-3('05)	~350 <sup>3</sup>	~400 <sup>3</sup>	20 <sup>3</sup>	MODIS
AVNIR-3	NASDA	ALOS-2('07)	250	230	240	LATI?
LISS-III, IV	ISRO	IRS-2A,B (> '00)?	81	85	37.7	LATI?

## NOTES.

1. EE - Earth Explorer, EW - Earth Watch, ALOS - Advanced Land Observing Satellite, IRS - Indian Remote Sensing Satellite.
2. Accommodation resources for Meteor/3 version.
3. Accommodation resources based on Phase B results.

# CONCLUSION

- **CONTINUING TO IDENTIFY AND EVALUATE ADVANCED TECHNOLOGIES AND SYSTEM ARCHITECTURES FOR MISSION**
  - **DETERMINED THAT SCIENCE REQUIREMENTS CAN BE MET THROUGH A COMBINATION OF ADVANCED AND ALTERNATIVE TECHNOLOGES**
- **EVALUATING FEASIBILITY OF MULTIPLE SPACECRAFT APPROACH**
  - **SCIENCE**
  - **TECHNOLOGY**
  - **COST**
- **INVESTIGATING EXPANDED (E.G. HYPERSPECTRAL) AND COMPLEMENTARY E.G. ACTIVE) MEASUREMENTS MADE POSSIBLE THROUGH ADVANCED TECHNOLOGY**